

Extensive, detailed tabulations of the various forms of tuberculosis, and of combinations of tuberculosis in different parts of the body, as well as the association of tuberculous with non-tuberculous disease, as observed at autopsy, have been carried out. It is hoped that before the end of another year, these tabulations may be completed. Study of the

incidence of tuberculosis and other lesions at autopsy may lead to greater ability to recognize factors that may be associated with susceptibility to infection, disease and resulting death. This in turn may bring greater ability to interpret the factors affecting these changes and to devise measures which may accelerate the eradication of tuberculosis.

## The Present-Day Usage of Pneumothorax in the Treatment of Pulmonary Tuberculosis

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### SUMMARY

*The patient with tuberculosis must heal himself. Collapse measures help in the healing process by making the environment of the tubercle bacilli in the lungs more intolerant of multiplication and spread. The usage of pneumothorax has decreased; ten years ago it was used for over 50 per cent of patients, now for less than 10 per cent. This reduction in usage is not a condemnation of the procedure but an index of the more judicious application of the treatment as adjuvant to other accepted forms of therapy. Pneumothorax, because it is so versatile and flexible, lends itself most effectively to combination with other collapse procedures. Its use for well selected purposes is still indicated, but in much more narrow limits than previously applied.*

THE patient with tuberculosis must cure himself. The final conquest or destruction of the tubercle bacilli is a victory of the body itself. Physicians guide and assist the resisting forces of the diseased body against the rapid multiplication and spread of the invading germs. The general measures of rest and good nutrition remain basic in the treatment. All measures of collapse therapy are clumsy and extravagantly inefficient; the more involved the procedure, the more expensive it is in functional loss to the patient. The ideal cure of any disease is the total eradication of it with the least resulting loss of function of the involved tissue or organ. Measures of treatment should be selected and applied with this always in mind. After all, surgical measures involving resection of parts and permanent loss of functions, in varying degrees, represent defeat of

medicine. This is not the fault of the surgeon. It is more the fault of the physician and of the limitations of medical knowledge which permit the disease to go on unprevented and undiagnosed until it has reached such stages as demand the serious loss of function to win life.

Surely all physicians are looking forward to the day when all collapse measures can be described as clumsy methods of the past, rather than to the continued development and refinement of more procedures entailing removal and loss of function, even though the technical accomplishment carries credit and glory. Research for the accomplishment of cure of tuberculosis is and must remain in the realm of prevention, of early diagnosis, and of specific bactericidal agents to stop the development of such stages of disease as require collapse therapy. Yet, until those goals are achieved, the measures which must be utilized to save life, clumsy as they may be, cannot be abandoned and efforts to improve them must continue.

Pneumothorax, as a treatment for pulmonary tuberculosis, has had wide usage all over the world for over 40 years. No other active definitive method of treatment has had such universal application. Surely such long usage by physicians of all beliefs, opinions, and convictions as regards rest, climate, specific cures, surgical procedures, and psychosomatic attitudes must have brought out the good and evils of the treatment. When pneumothorax was introduced as a form of treatment, it was the only method of collapse therapy known. It was first received with misgivings, damnations, and limited application; it was first applied in hopeless cases when rest, food, and climate had failed. Gradually, a safe, sane level of application was found, but still its advantages were pushed and extended into the zone of hazards and uselessness because many times there was no other treatment to offer and trial was justified. This era, extending into the time of the perfection of thoracic operations, was padded with overuse and misuse of the treatment. But the recog-

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nition and limitation of the wrong use have not eliminated the proper use nor changed the acceptable proven indications.

The patient well chosen for treatment with pneumothorax is one in whom the tuberculous lesion is of such character and position that the extra relaxation of the involved tissue, brought about by the air in the pleural space, will hasten and make more certain healing with minimum destruction and permanent loss of function. There can be no hard and fast specific general rules of choice. The selection may depend upon the patient himself, his race, color, temperament, and his ability or willingness to take rest. The quality of lesion should be such that a considerable part of it is exudate capable of being absorbed or of healing with minimal scar. Any cavity present (and most often cavitation is demonstrable by x-ray studies) should be of such character and position as will permit of closure by relaxation of the surrounding lung tissue. Sputum positive for tubercle bacilli may be accepted as evidence of necrosis and ulceration, even though no cavity is observed on x-ray films. In the area to be collapsed, there must be no accepted evidence of bronchial obstruction which cannot be relieved. The significance of bronchial lesions in the area, as far as determining the usage of pneumothorax is concerned, has been considerably changed since the advent of streptomycin and other new drugs into treatment. Likewise, the method of dealing with that type of thin-walled cavity which indicates bronchial obstruction, has been altered with the use of the newer agents.

Bed rest should be given thorough trial before pneumothorax is considered. Bed rest for three months to study the ability of the body to cope with the lesion should be the rule before pneumothorax is undertaken, unless circumstances develop which unquestionably threaten the life of the patient or indicate unequivocally in less time that bed rest alone is not adequate. Now, for each patient it must be decided whether or not streptomycin or others of the new drugs shall be added to bed rest in this period. At the end of three months of observation and treatment, all clinical, laboratory, and x-ray findings must be studied to determine whether the healing process is adequate or further help is necessary. Experience has taught certain critical lessons and contraindications. Years ago, a study of the use of pneumothorax in cases of exudative lesions was made at the Dunham Hospital. The review clearly showed that the institution of pneumothorax in patients with exudative lesions and having toxic manifestations was extremely hazardous because of the high incidence of empyema. It is noteworthy, however, that in that institution there was a large proportion of negro patients. Most negroes with tuberculosis have exudative lesions. Therefore, in the Dunham series a relatively large number of the patients who had lesions of a nature suitable for pneumothorax were of a race for which the operation has proven less successful. By withholding

pneumothorax in cases in which there are toxic manifestations, the medical staff at Dunham has greatly reduced the incidence of empyema in connection with the procedure.

Streptomycin and other new drugs have greatly reduced the time necessary to overcome toxic manifestations and have made the use of pneumothorax safer than ever in such cases. Despite these precautions, however, results of pneumothorax for negroes are not as good as for white patients, and the hazards are greater. While the hazards are also greater for patients with diabetes, who as a rule have exudative lesions, the judicious use of insulin and streptomycin makes the procedure safer and more effective.

The Dunham Hospital has a patient capacity of about 480. It is always about 90 per cent full. On the average, about 33.3 per cent of the patients are negroes. Previous to 1940, pneumothorax treatments were given to more than 50 per cent of all the patients. In four consecutive years, 1936 to 1940, there were 898 patients treated with pneumothorax. In those four years, 112 cases of tuberculous empyema developed. In 1944, 115 of 444 patients had pneumothorax treatments. Twelve of the 115 had bilateral pneumothorax. Empyema developed in eight (6.9 per cent) of the cases in which pneumothorax was started. The procedure was considered to be mechanically and therapeutically successful in only 37 (32.1 per cent) of the cases in which it was started. At present there is an adult census of 470 in the hospital. Pneumothorax treatments are being given to 32 patients (6.9 per cent). The more critical selection of cases is indicated by the fact that of the 32 cases in which pneumothorax is being given, the treatment is considered mechanically and therapeutically effective in 28 (87.5 per cent). There is one case of bilateral application. Only two cases of empyema have developed, and one of these followed spontaneous pneumothorax and bronchopleural fistula. Of these 32 patients, ten (31 per cent) are negroes, which is about the same as the percentage ratio of negro to white patients in the hospital. Further evidence of the drop in usage of pneumothorax treatments is that in Cincinnati in 1940 there were operated at the General Hospital two pneumothorax clinics a week, with an average attendance of 30 patients per clinic. Today there is one pneumothorax clinic a week at the Health Center, with an average attendance of 15 patients. This represents a drop of 75 per cent. The usage in private practice has had a corresponding turn. The author looks upon this downward trend as indicative of a more critical, refined choice of cases for the use of the procedure. Its overuse and misuse are no longer necessary, because other methods of collapse by pneumoperitoneum, phrenic nerve crush, and thoracoplasty, and total resections of diseased lung can be safely and judiciously used where pneumothorax is no longer the prime choice of treatment. The abuse is gone and the proper use becomes a part of the entire strategic plan of treatment in

which many procedures must be considered and used alone or in combinations.

The probable effectiveness of pneumothorax in a given case can sometimes be quickly determined by x-ray studies soon after the air is introduced. If the lung is completely surrounded by air, with no pleural adhesions and the involved tissue area is shown to be relaxed with evidence of cavity closure, good results seem probable. On the other hand, if there are broad adhesions overlying the lesions, preventing relaxation of tissue or cavity closure, the procedure is not likely to be effective. Between these limits are all gradations of conditions involving position, size, and character of cavity, a lesion incapable of compression, or adhesions of differing position, number, and quality. Each patient must be studied individually, which may entail thoracoscopic observations and a period of trial to observe the effect of continued treatment. The procedure can always be modified or stopped.

The accumulation of fluid in the pleural space during pneumothorax treatments is a problem which has provoked answers of wide extremes. Some physicians would stop the pneumothorax at the first hint of fluid. Others are more tolerant of such accumulations. It is known that fluid in small amounts comes and goes in about 25 per cent of all cases of long-continued pneumothorax. Individual experience and circumstances of treatment no doubt establish the practice of each physician. It is probable that those who in private practice give large numbers of pneumothorax refills in the office, have a much more lenient attitude toward fluid accumulation than do physicians in institutions. All agree, however, that fluid persisting for weeks, increasing in amount or becoming increasingly turbid or bloody, or giving rise to established toxic signs, or showing evidence of pyogenic nature by microscopic or bacteriological studies, calls for termination of pneumothorax. Of course, the transitory presence of fluid after certain procedures, such as pneumonolysis, must be taken into consideration.

At times, circumstances compel continuance of pneumothorax in cases in which it is not fully satisfactory and effective—cases in which bed rest has proved to be inadequate. The cavity may remain open and the sputum positive for tubercle bacilli. Many physicians, however, have had the experience of seeing such a cavity close and the sputum become bacilli-free after the "ineffective" pneumothorax has been abandoned. Explanation is inadequate, but it may be postulated that the short-term relaxation of lung brings about, in such cases, sufficient absorption of exudate and tissue change to permit the cavity to close on reexpansion. In fact, an adhesion may have held open a cavity which will close when the surrounding inflammatory changes have disappeared. This phenomenon, rare though it may be, only illustrates the flexibility in the usage of pneumothorax. A cavity in the lung is not feared simply as an anatomic hole, but because it usually offers an environment—extra moisture, extra oxygen, less

blood supply, less movement—in which the tubercle bacilli can live and multiply. From this thriving focus, there are open bronchial avenues of spread to other parts of the lungs, and out of the lungs to trachea, larynx, mouth cavity, stomach, and intestines. A continuously sterilized cavity would do no more harm than reduce function by loss of tissue. For this reason no effort should be spared in search for methods and means to sterilize permanent cavities.

The time for voluntary termination of pneumothorax is a question often discussed and variously answered. Often the answer is forthcoming and dictated by natural progress of events. The lung gradually expands, the normal part first, then the involved part, until the pneumothorax space becomes at last so small that the treatment must be stopped. It is to be hoped that this foreclosure process will be orderly and delayed to such time as will have allowed the lesion to become inactive, the cavity closed, and the sputum negative for tubercle bacilli. The time necessary for this is one to three years, in the best of circumstances. In those cases in which the indication for discontinuing pneumothorax is less clear-cut, judgment based on x-ray study of the reexpanding lung and on sputum examinations must dictate the stopping point. Experience has taught that if pneumothorax is too long continued, the lung may become incompletely expansible. This can best be avoided by watching the ability of the lung to expand and contract and the thickness of the visceral pleura. After these anatomic pathological points have been settled to the physician's satisfaction, the patient's willingness, ability, and opportunity to carry on with extra rest and physical limitations must be weighed in the final decision.

Among physicians treating tuberculosis there is uniform agreement that pregnancy in a patient with active pulmonary tuberculosis in whom the disease is well controlled by established methods of treatment offers no serious hazard to life or to the expectancy for recovery. On the other hand, if the disease is not controlled, then pregnancy is a definite hazard to recovery and to life. The occurrence of pregnancy may be a circumstance which calls for extra active treatment in a patient who has been doing well on bed rest regimen. If in such circumstances a lesion is not completely controlled, some form of collapse therapy may be necessary. Pneumothorax, if it can be effectively induced, then is the method of choice because of the adaptability and flexibility of application. The disturbance of respiratory function is temporary; it can be modified and stopped at will. Surely an active lesion, especially with cavity, or a lesion not completely stable, is given added protection and the chance of continued control is improved by effective collapse with pneumothorax in pregnancy, especially during labor and following childbirth when the position of the diaphragm is so suddenly and greatly changed.

The treatment of pulmonary tuberculosis is not a skirmish, not a battle, not a siege, but a long-

drawn-out war with activity on many fronts. When treatment is started it must be based on strategic plans to suit the patient for a duration of at least five years, and maybe for a long lifetime. The plan must be to stifle and eradicate the infection while preserving at a maximum the function of the diseased part. Extensions of the disease and complications in other parts of the lungs and other parts of the body must be dealt with quickly and as fully as possible. It is necessary to be in a position to change, modify, enlarge, combine, or stop the methods of treatment in use (if necessary and if possible) at any time, to meet new situations. Pneumothorax is the most flexible and versatile method of collapse therapy that can be applied. It can be lessened, enlarged, shifted from side to side, applied to both sides, combined with any other form of treatment—rest, drug, antimicrobial, or surgical—or stopped at will. It can sometimes be stopped and

restarted with surprising effectiveness. A treatment which has had such long and widespread effective usage, the value and limitations of which have been determined, is not one to be dropped. Rather, it is one to be preserved and utilized in better refinements of application so as to avoid abuses. It is to be used in its greatest effectiveness in combination with all other forms of treatment, with no undue claims made for accomplishments with it alone. As progress is made in methods to prevent tuberculosis and to diagnose and treat it early when it does occur, the goal is minimum sacrifice of tissue or function. Progress toward that goal will eventually reduce the need for the clumsy methods of collapse and resection which now must be used; and the last of these methods to be abandoned will be the flexible, versatile pneumothorax, narrowed more and more in its application but effective to the last well chosen case.

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## The Pathogenesis of Tuberculosis as an Ebb-and-Flow Struggle Between Two Variable Antagonists

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THE pathogenesis of tuberculosis has become clarified over the last few decades so that we now may view the struggle between the host and the parasite as we would any contest where the stakes are survival of one or the other of the antagonists. Until recent times, however, knowledge was meager. Little by little, men like Bayle and Laennec parted the curtains on some of the elementary features of the tuberculous process.

Bayle was first to describe the miliary tubercle as a small "gray granulation." Laennec observed that many miliary tubercles had soft yellow centers and that they seemed to become larger as they became older. He reasoned that Bayle's hard gray granulations were merely the "green fruit" while the yellow miliary tubercles were the "ripe fruit." This is probably the only error committed by the immortal Laennec. He was not wrong, however, in his contention that all forms of tuberculosis were due to one cause. Too much tribute cannot be paid to his keenness of insight into the pathologic character of the disease. With much more information at hand a half century later, Virchow tried to tear down Laennec's unity theory, but only confused the scientific world for a time by his fallacious "dualism," a doctrine proclaiming that tuberculosis was a dual process of inflammatory phthisis and the tumorous

tuberculosis. As a result of the enthusiasm for this contention Niemeyer made the preposterous statement that the worst thing that could happen to a phthisical patient was to become tuberculous. Virchow's influence held great sway throughout the latter part of the century. Fragmentary knowledge was added, such as that of Küster's epithelioid tubercle, Langerhans' giant cells, Reinhardt's caseous pneumonia and Weigert's intravenous tubercles. Parrot and later Küss laid the groundwork for the present understanding of primary tuberculous infection. These observations were made before the discovery of the tubercle bacillus; afterward in rapid sequence came the works of H. Albrecht, E. Albrecht, Ghon, Ranke and others, amplifying Parrot's pioneer studies. Since then dozens of names have been added to the list of investigators, and many theories have been proposed.

It is the desire of the author here to by-pass much that has been written and go directly to the most fundamental aspects of pathology and pathogenesis of tuberculosis. This will involve a consideration first of the host, secondly of the bacillus, then of the two in active encounter with each other, followed by a discussion of the resultant forms the disease may assume.

In few if any other diseases do we meet such a variable pattern as presents itself in tuberculosis. The process may be infinitesimal, one of limited involvement that heals promptly; or it may be over-

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